

# Planning for November Keck SSC

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# Key Questions

1. What instrumentation projects to put forward for NSF funding or small upgrades funded by CARA?
2. Should UCOAC endorse Keck AOAG recommendation to move forward with NGAO?
3. Should UC and Caltech re-examine their partnership agreement now to enable improved institutional fund-raising for WMKO?
4. How can UC help to ensure that UC-WMKO instrumentation is successful? (& assure their partnership share?)

# WMKO Projects that Have Been Approved for NSF Proposal

- **KCWI –red**
  - PI = C. Martin (Caltech)
  - Estimated cost = \$2.8M
  - Funding Target = NSF-MRI
    - Unsuccessful 2012 (passed PDR, split from KCWI-blue to finish under TSIP)
    - Plan resubmit Jan 2013
- **OSIRIS Detector Upgrade**
  - PI = J. Larkin (UCLA)
  - Estimated cost = \$1M
  - Funding Target = NSF-ATI (WMKO?)
    - Plan to submit to NSF-ATI this round
- **K1DM3**
  - PI = X. Prochaska (UCSC)
  - Estimated cost = \$1.7M
  - Funding Target = NSF-MRI
    - Unsuccessful 2012
    - Resubmit?

# NGAO – Well Advanced But Funding Limited

- NGAO
  - Passed Preliminary Design Review in June 2010
  - Estimated remaining cost
    - AO = \$37M
    - DAVINCI = \$13M
  - Board placed hold on until funding path clear
  - New Opportunities on Horizon
    - Mid-scale recommendation Astro2010 & NSF AST Portfolio Review (Aug 2012)
    - Keck 20<sup>th</sup> Anniversary Celebration
  - Keck AO Advisory Group
    - Keck SSC formed this sub-committee this summer
    - Is NGAO still long-term AO strategy?
    - Recommendation – Yes, move forward.
  - UCLA Development office strongly engaged
  - UCOAC endorsement?



# Issues

## – ***Original WMKO Operational Model run out of gas before 2018***

- ***Key decision in 2005 that effected this***
- ***Instruments Originally funded Entirely by CARA***
  - LRIS-red (1993; Caltech)
  - HIRES (1994; UCSC)
  - NIRC (1994; Caltech)
  - LRIS-blue (2000; Caltech)
  - LWS (1996; UCSD, UCB)
  - HIRES image rotator (1997; UCSD)
  - KCAM Modification (1998; UCLA)
  - ESI (1999; UCSC)
  - NIRSPEC (1999; UCLA)
  - K2 AO [NGS] (1999)
  - NIRSPEC AO Upgrade, NIRSPA0 (2000)
  - NIRC2 (2001)
  - K1 NGS-AO (2001)
  - DEIMOS (2002)
  - K2 LGS-AO (2004)
  - Interferometer (2004)
  - HIRES Detector Upgrade (2004)

# Issues

- ***Original WMKO Operational Model run out of gas before 2018***
  - ***Instruments funded Entirely with some or all TSIP***
    - OSIRIS (2005)
    - MOSFIRE (2012)
    - KCWI-blue (TBD)
  - ***Instruments funded Entirely outside TSIP***
    - K2 Wave Front Controller Upgrade (2007) – Keck Foundation
    - K1 AO Upgrade (TRICK) – NSF-ATI
    - K2 AO Upgrade (Center Launch) – NSF-MRI
    - K2 AO Upgrade (Laser) – Keck Foundation, Moore Foundation & Friends of Keck
  - ***Mirror Segment Microfractures proposed for current night “exchange”***



# UCOAC Input

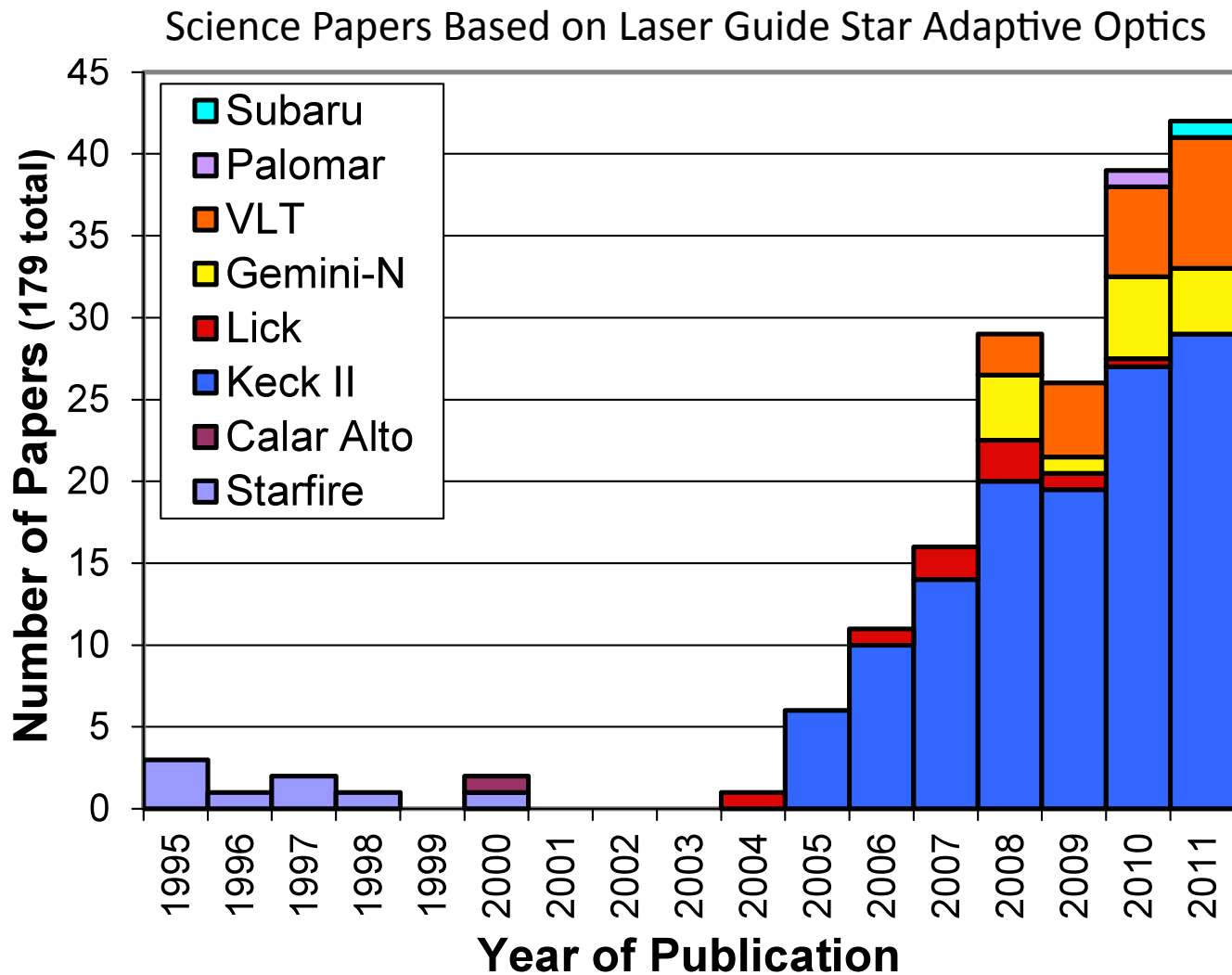
- **NGAO go-ahead**
  - *For mid-scale?*
  - *For Gala vision and fund-raising?*
  - *Engage UC development?*
    - *NGAO Observatory Tour at Gala? Other Ideas?*
    - *If so, does UC gain nights?*
- **K1DM3 resubmission**
  - *Expanded TDA operational model?*
  - **Straw-man expansion**
    - *Multi-institution ToO program*
    - *Cadence observing (up to 1hr per night)*
    - *Optimize observing to conditions (TAC-approved bad-seeing programs)*
  - *Expanding these activities may mean reducing other operations*



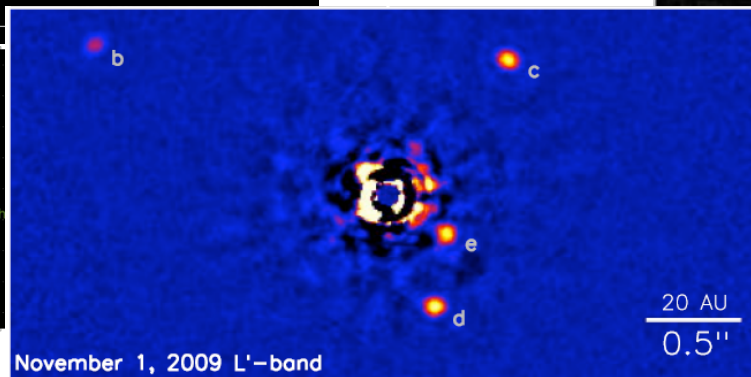
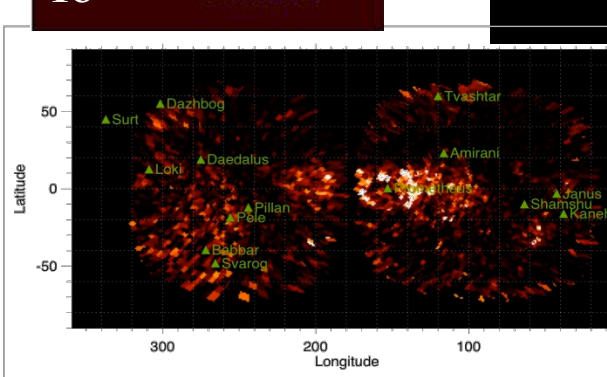
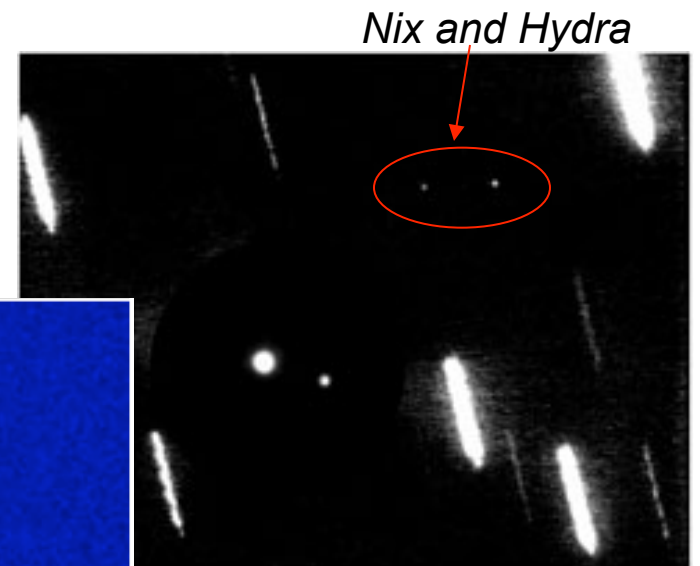
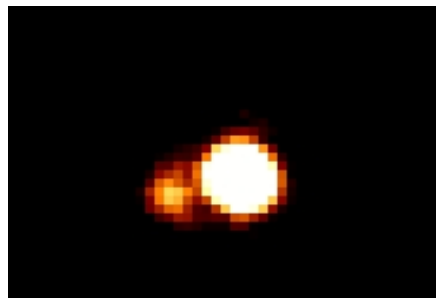
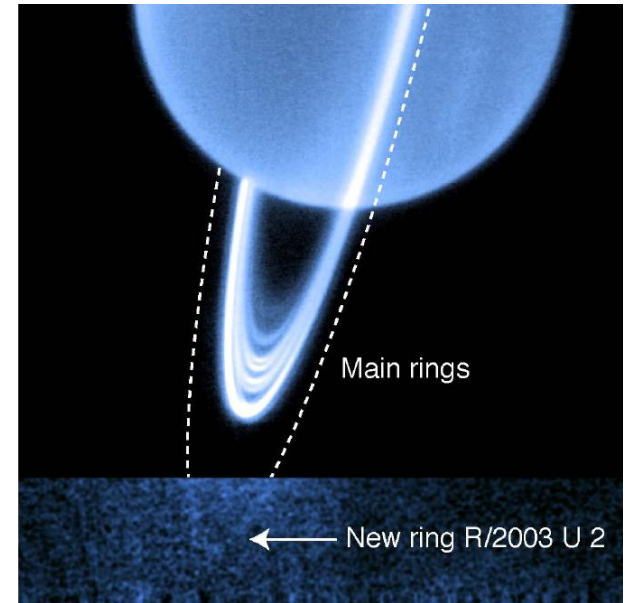
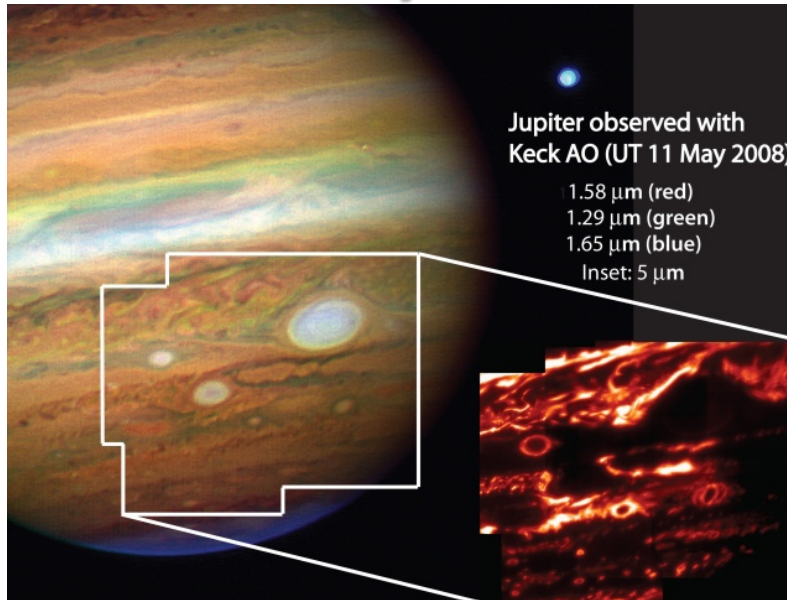
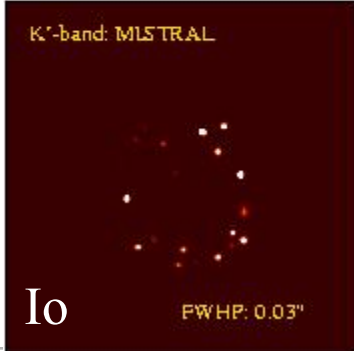
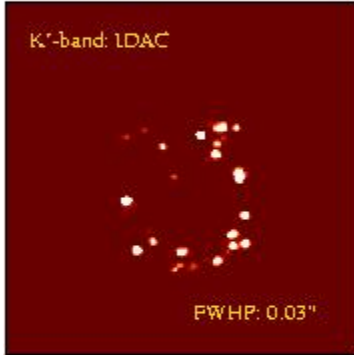
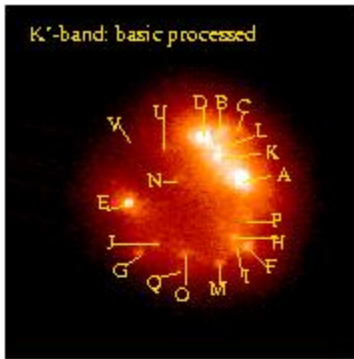


# Slides from AOAG presentation at Keck Science Meeting

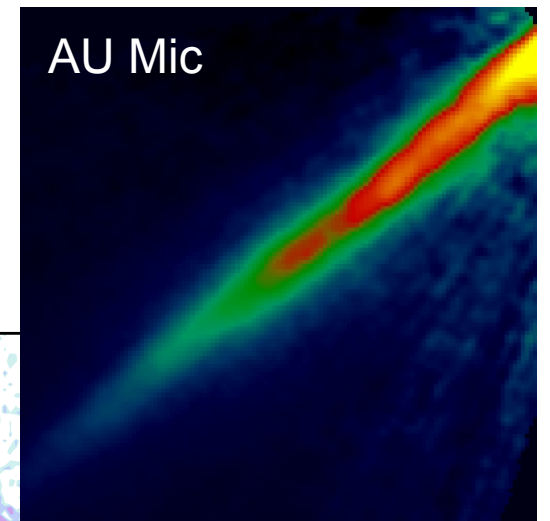
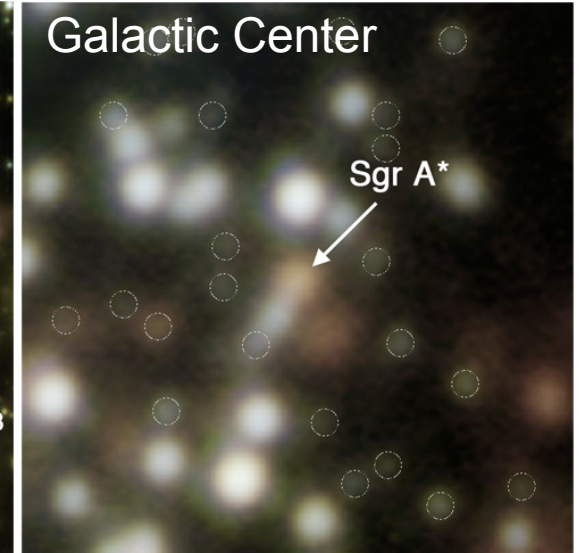
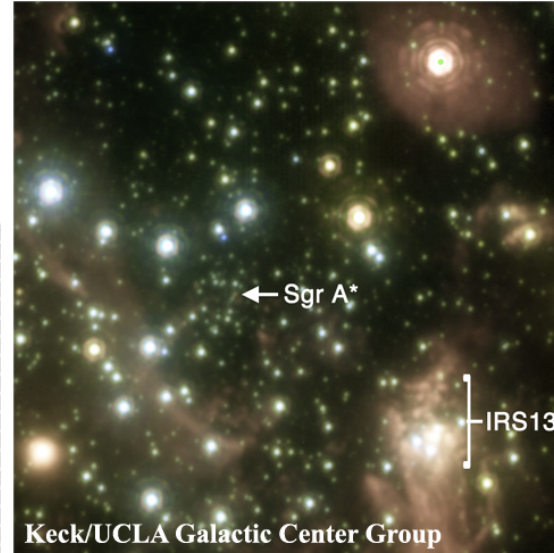
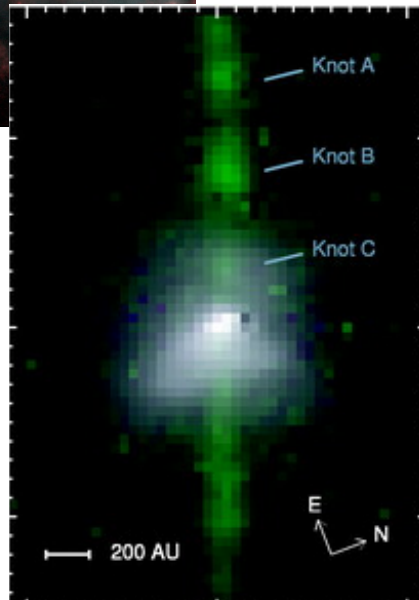
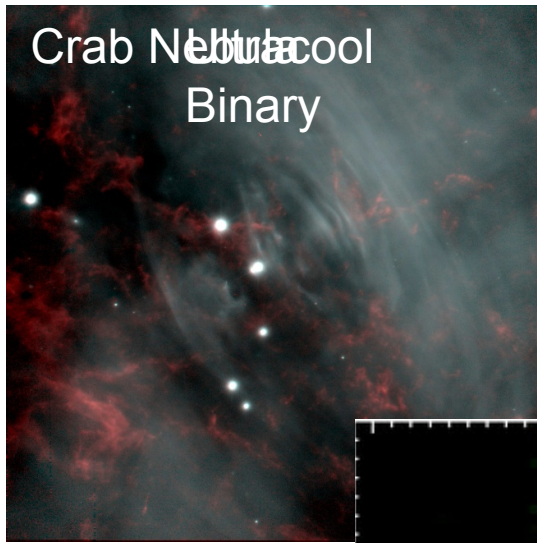
# Keck Leads in the field of Adaptive Optics



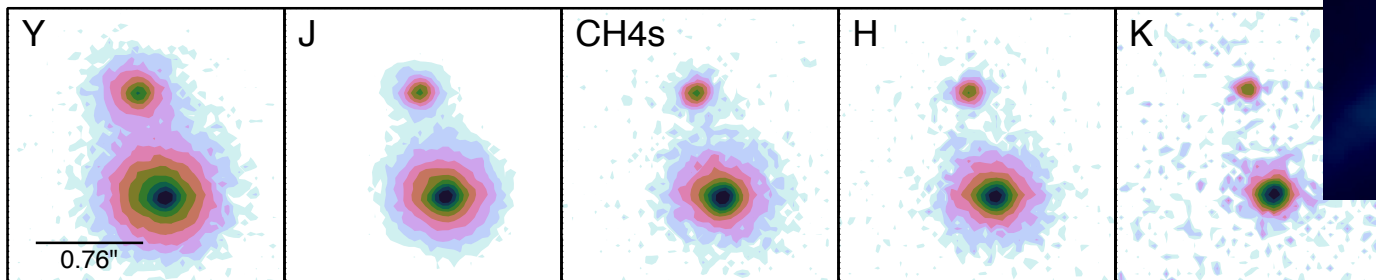
# Solar System Science



# Galactic Science

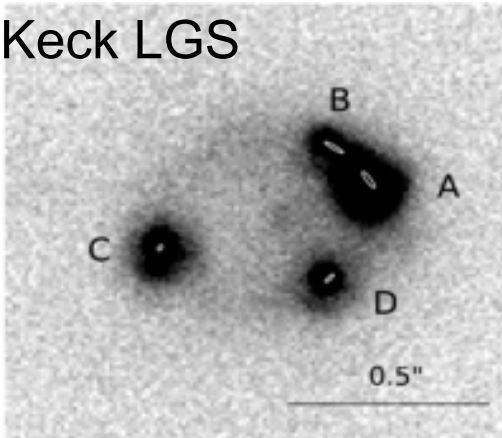


WISE J1217+1626AB

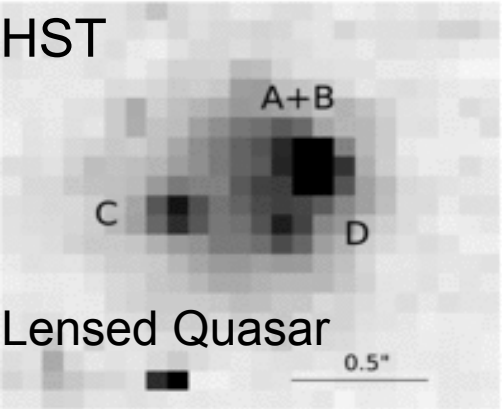




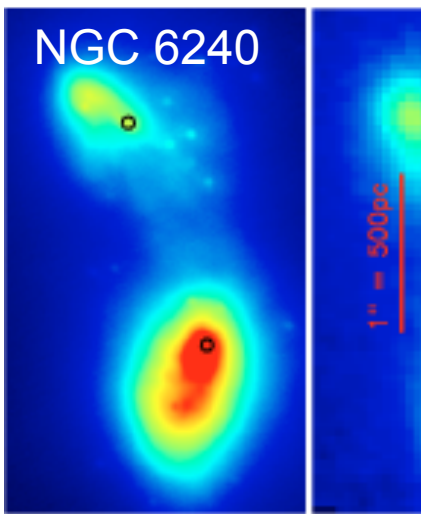
Keck LGS



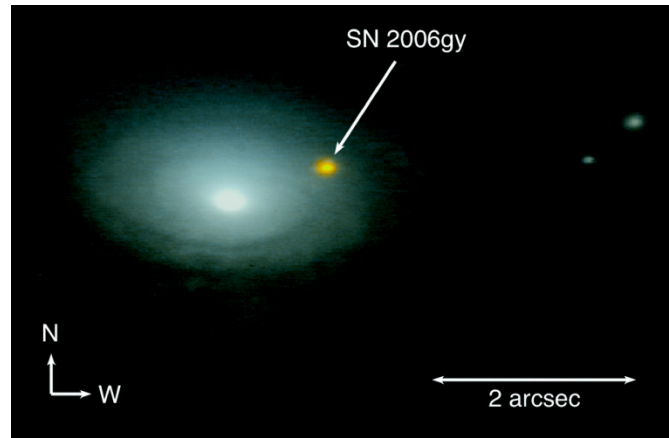
HST



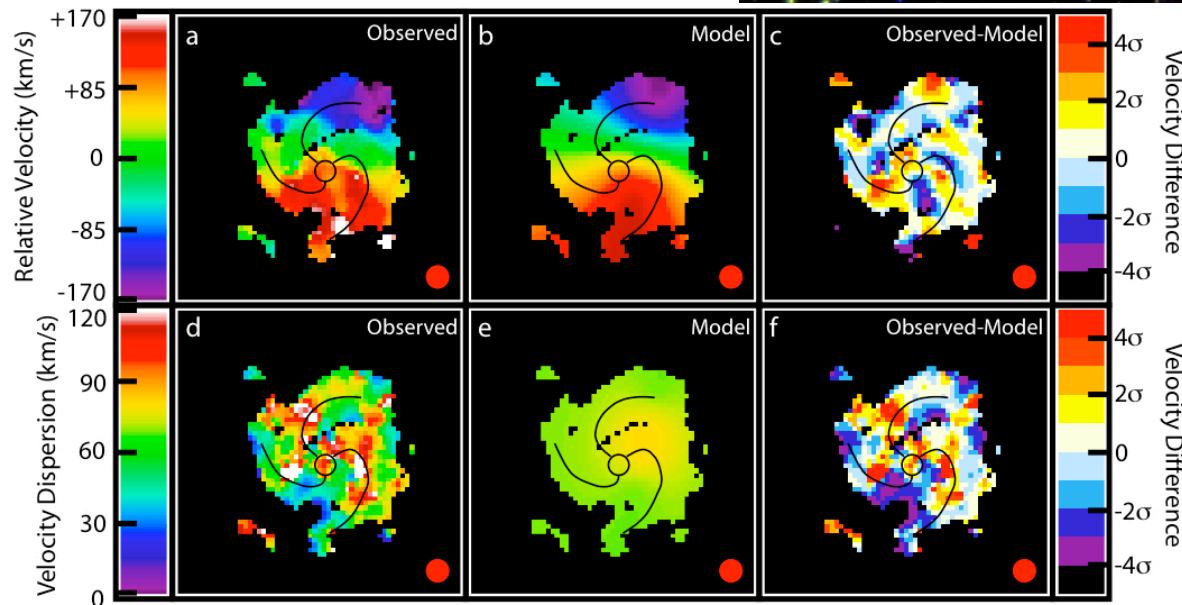
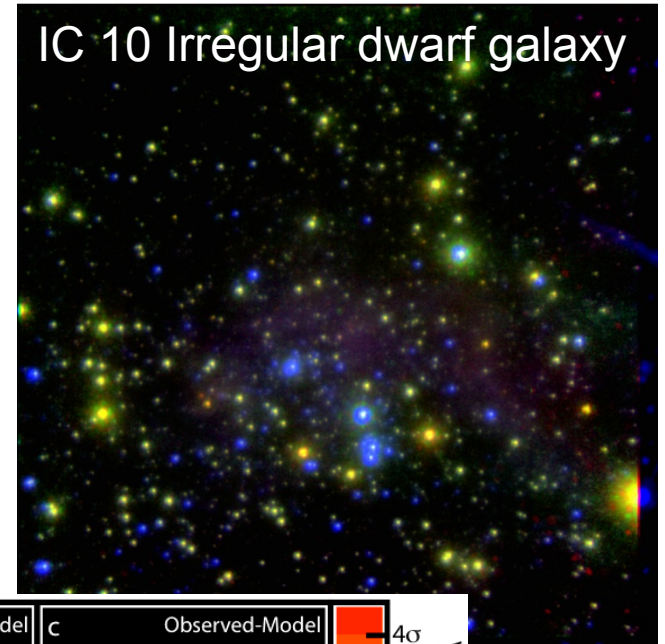
Lensed Quasar



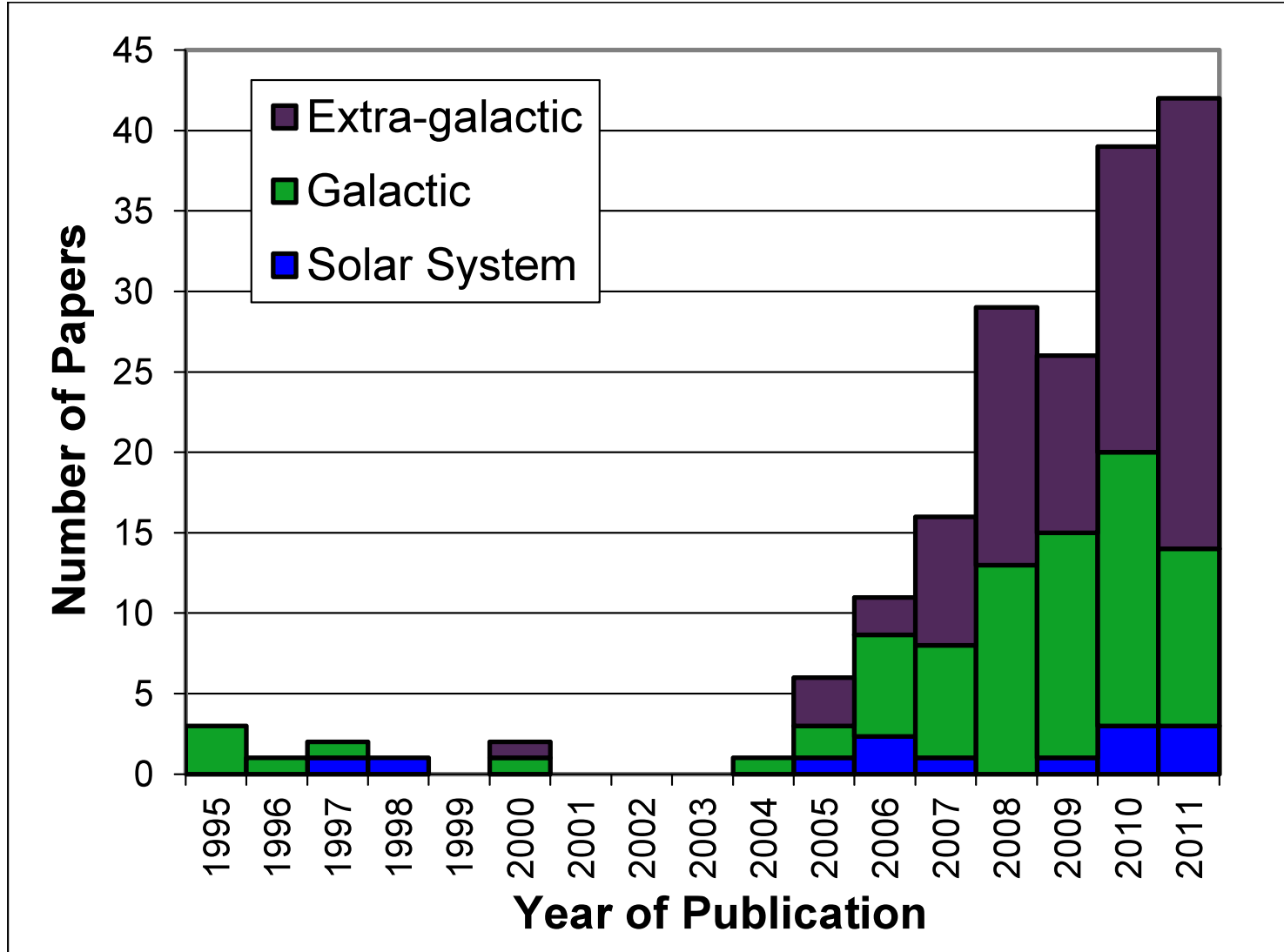
# Extragalactic Science



IC 10 Irregular dwarf galaxy

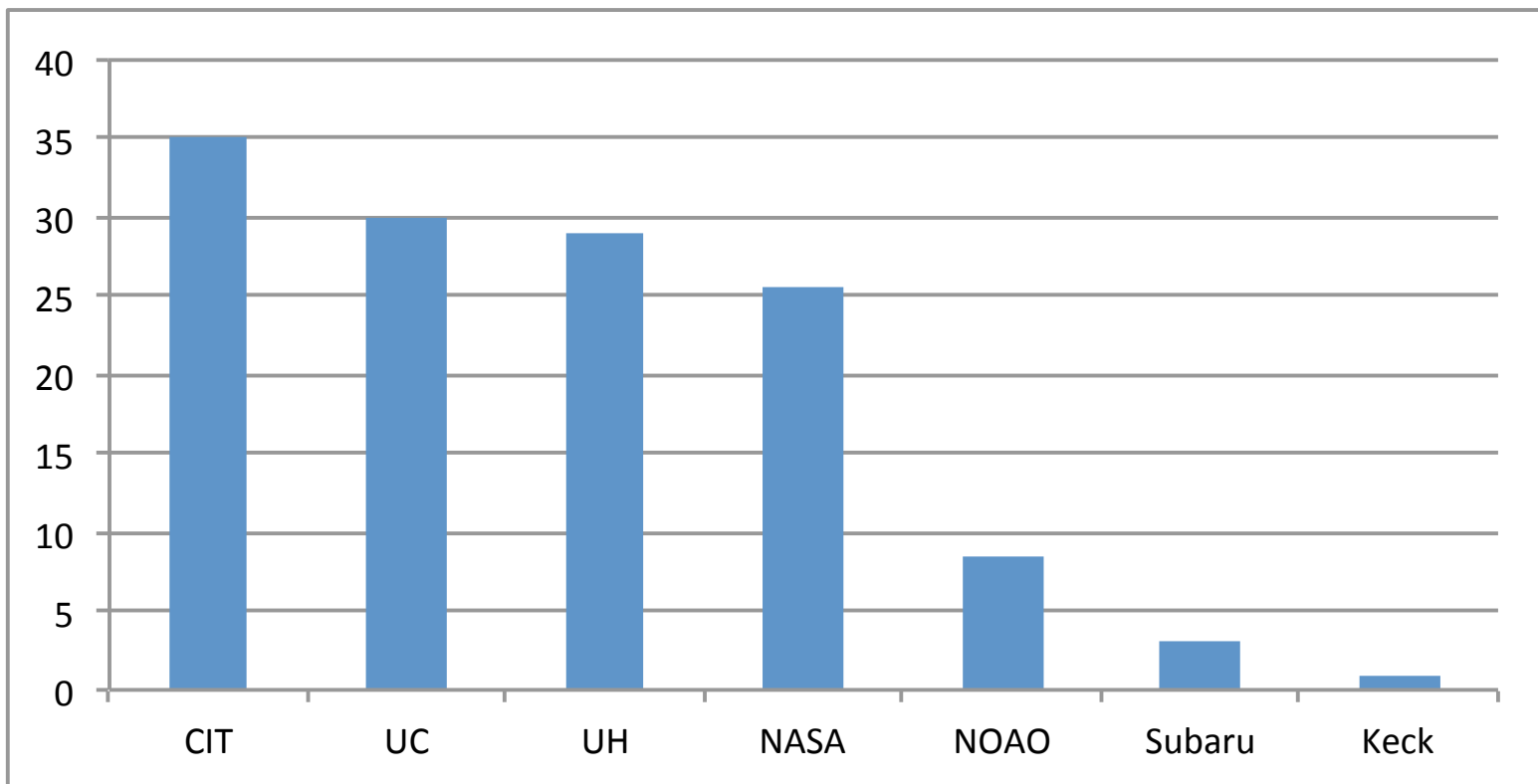


# Rapid Growth in Extra-Galactic AO Science Since Advent of LGS

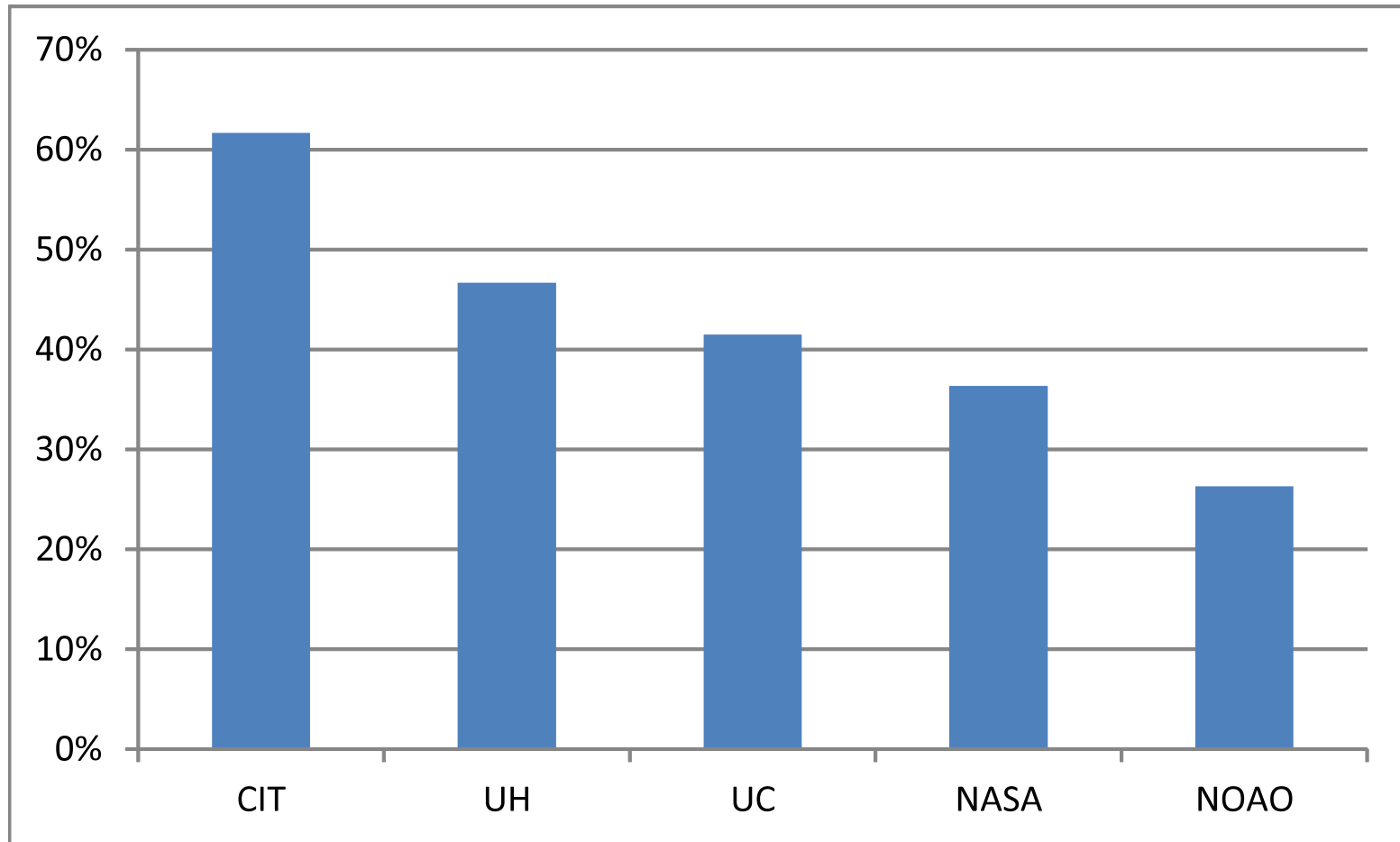


# Broad Usage Across Community

Number of Unique PI's by Partner Institution (2008-2012)



# AO PIs as a % of all Keck PIs in 2011



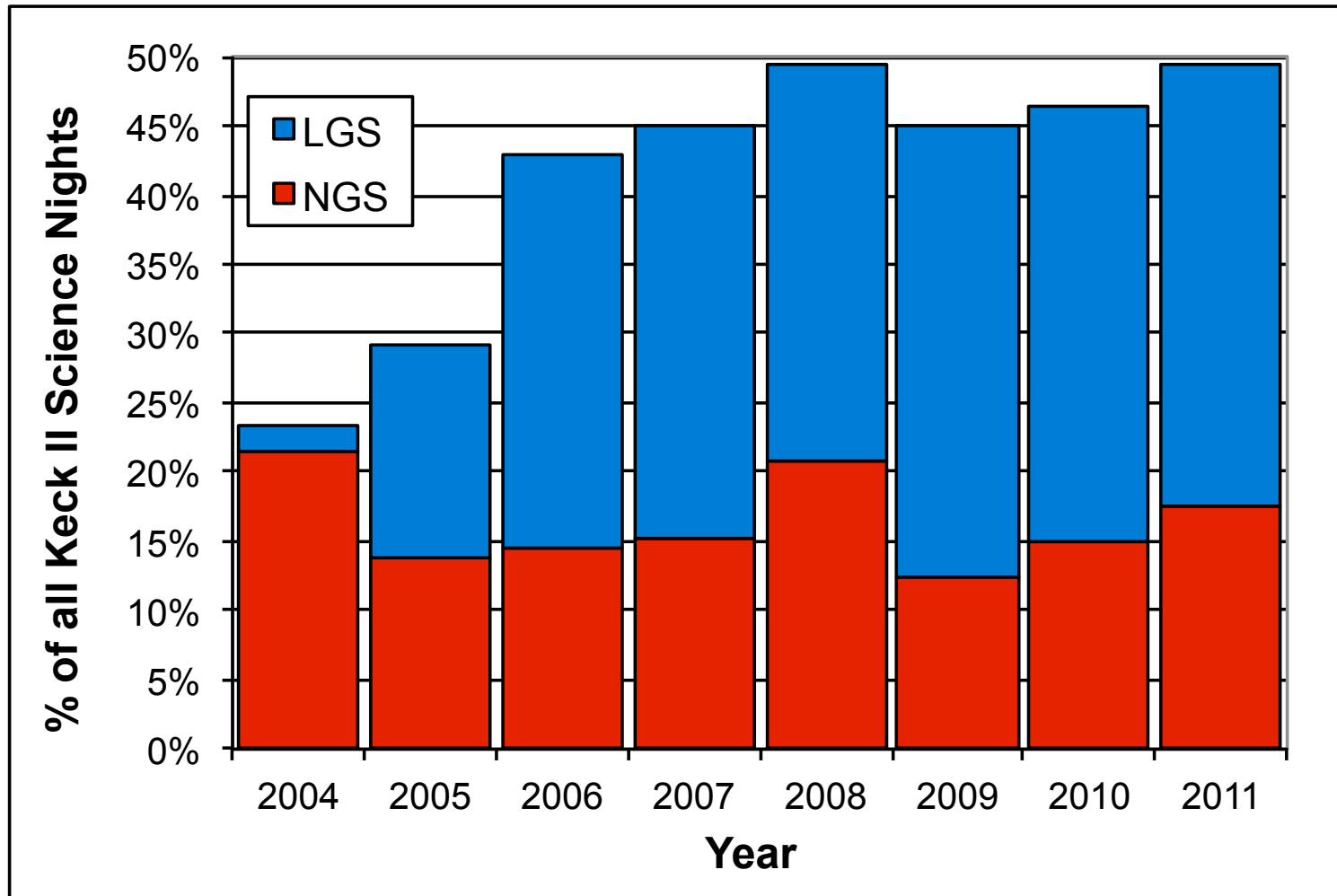


# High Demand by Graduate Students

- Of the 43 PhD awarded 2009-2010 based on Keck data
  - At least 42% of these contain Keck-AO data
  - 49% of these students appeared as co-authors on papers with Keck-AO
  - 90% of those that won Prize Postdoc Fellowships used AO in their thesis (9/10)



# Number of AO Award Nights is High



Keck AO has Already had Tremendous  
Science Impact

but

Full Potential of AO Has Not Yet Been  
Achieved

# Next-Generation Adaptive Optics (NGAO) Primer



Peter Wizinowich  
Principal Investigator



Claire Max  
Project Scientist

# Capabilities Based on Broad Science Reach

## **Key Science Goals**

**Understanding the Formation and Evolution of Today's Galaxies since  $z=3$**

**Measuring Dark Matter in our Galaxy and Beyond**

**Testing the Theory of General Relativity in the Galactic Center**

**Understanding the Formation of Planetary Systems around Nearby Stars**

**Exploring the Origins of Our Solar System**

## **Key New Science Capabilities**

**Near Diffraction-Limited in Near-IR (K-Strehl  $\sim 80\%$ )**

**AO correction at Red Wavelengths ( $0.7-1.0 \mu\text{m}$ )**

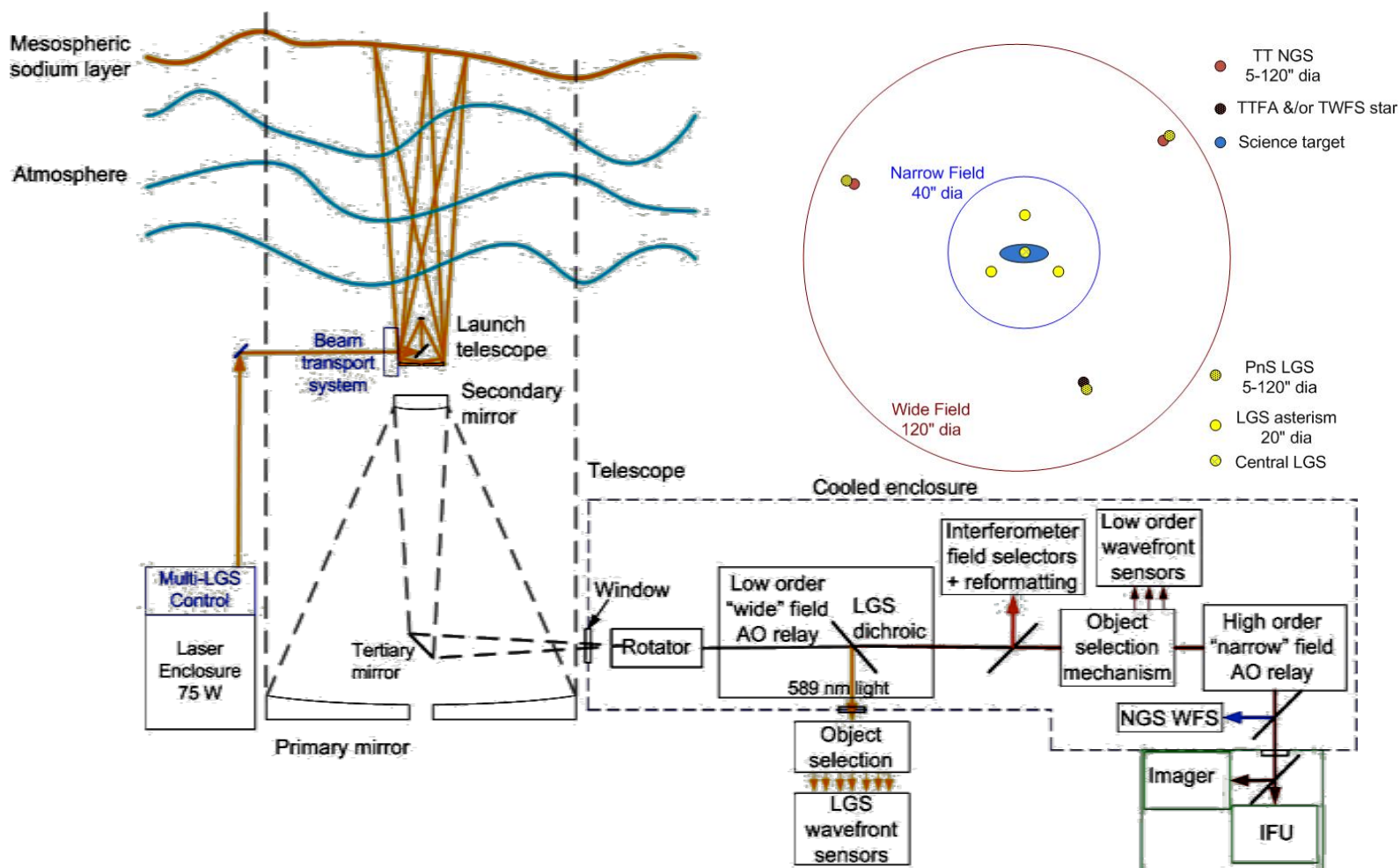
**Increased Sky Coverage**

**Improved Angular Resolution, Sensitivity and Contrast**

**Improved Photometric and Astrometric Accuracy**

**Imaging and Integral Field Spectroscopy**

# NGAO System Architecture



High Strehl = Multiple Lasers & High Order DM

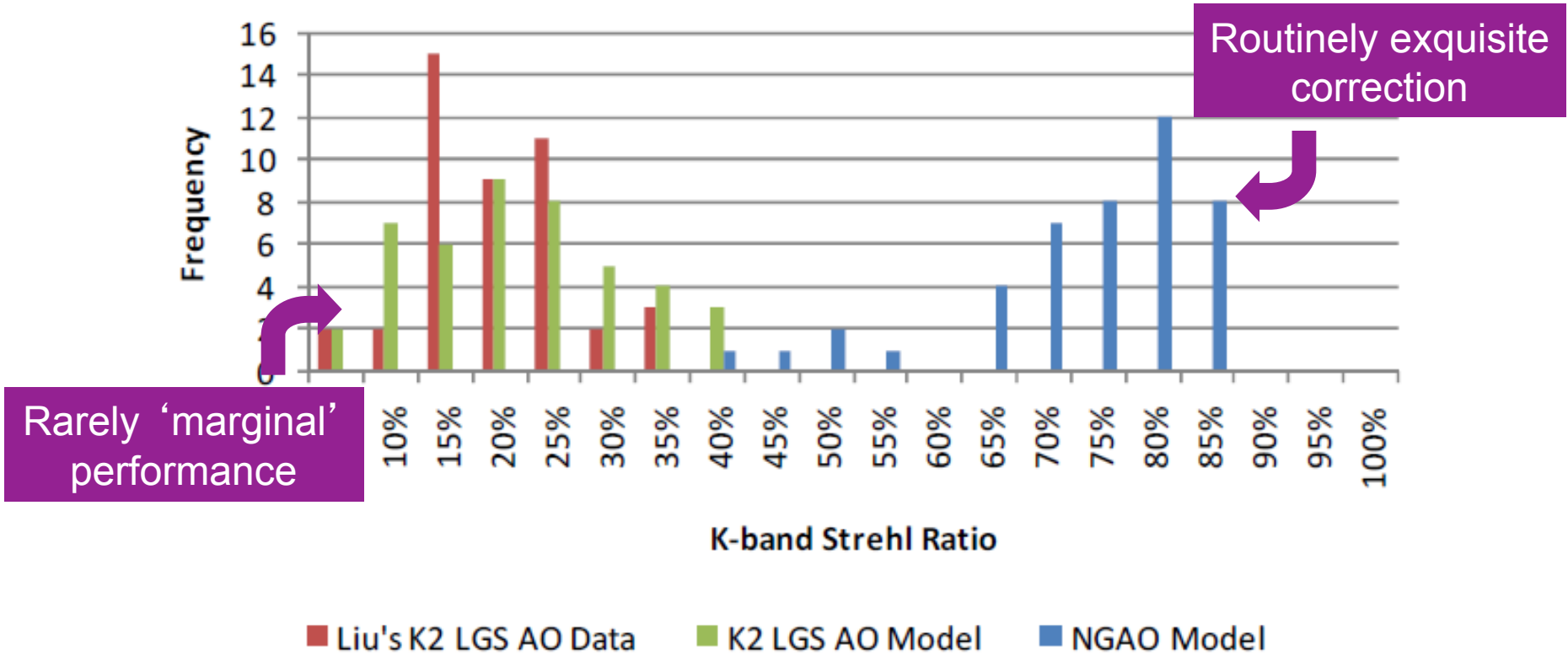
High Sky-Coverage = AO-corrected NIR Tip-Tilt sensor & Multiple-Tip/Tilt stars

High Sensitivity = above + cooled enclosure



# NGAO will change the AO observing experience

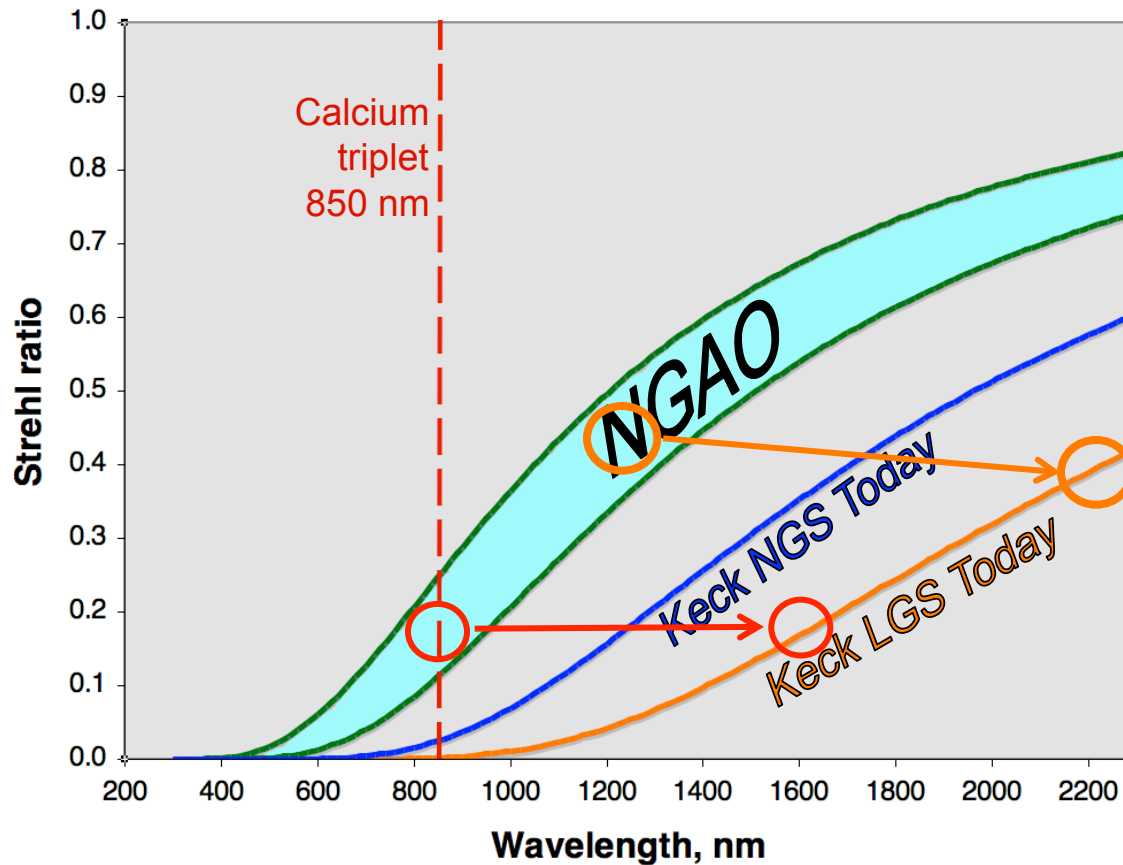
AO performance comparison



Monte Carlo performance estimate simulating 44 nights observing (Galaxy Assembly science case), drawing random values for  $r_0$ , wind speed, sodium abundance, and zenith angle (KAON 716, Figure 12)

Includes comparison with M. Liu's measured K2 LGS data ( $\langle SR \rangle = 17\%$ ), the KAON 721 predict for K2 LGS ( $\langle SR \rangle = 20\%$ ), and NGAO predict ( $\langle SR \rangle = 70\%$ )

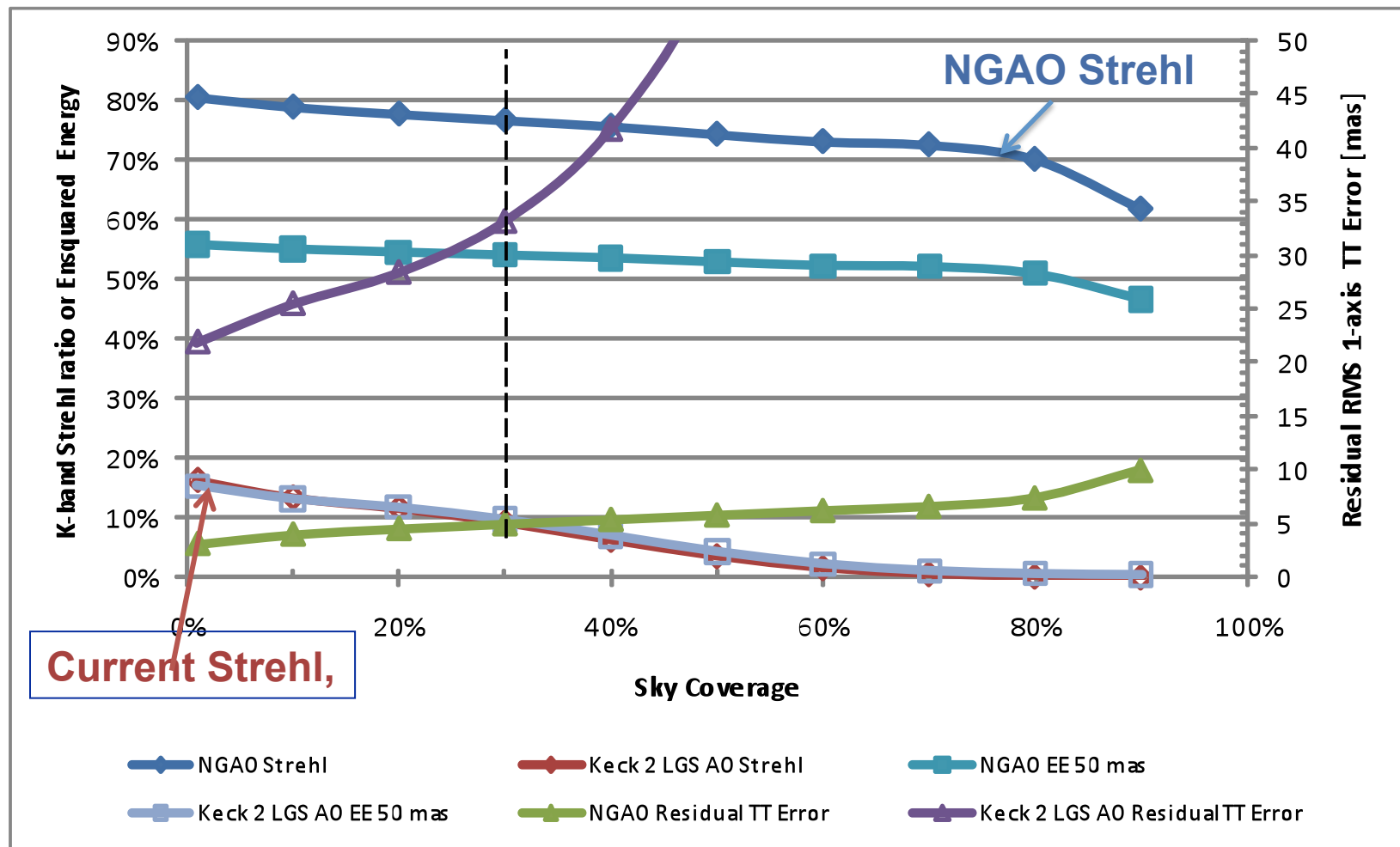
# How is NGAO different from Keck's AO today?



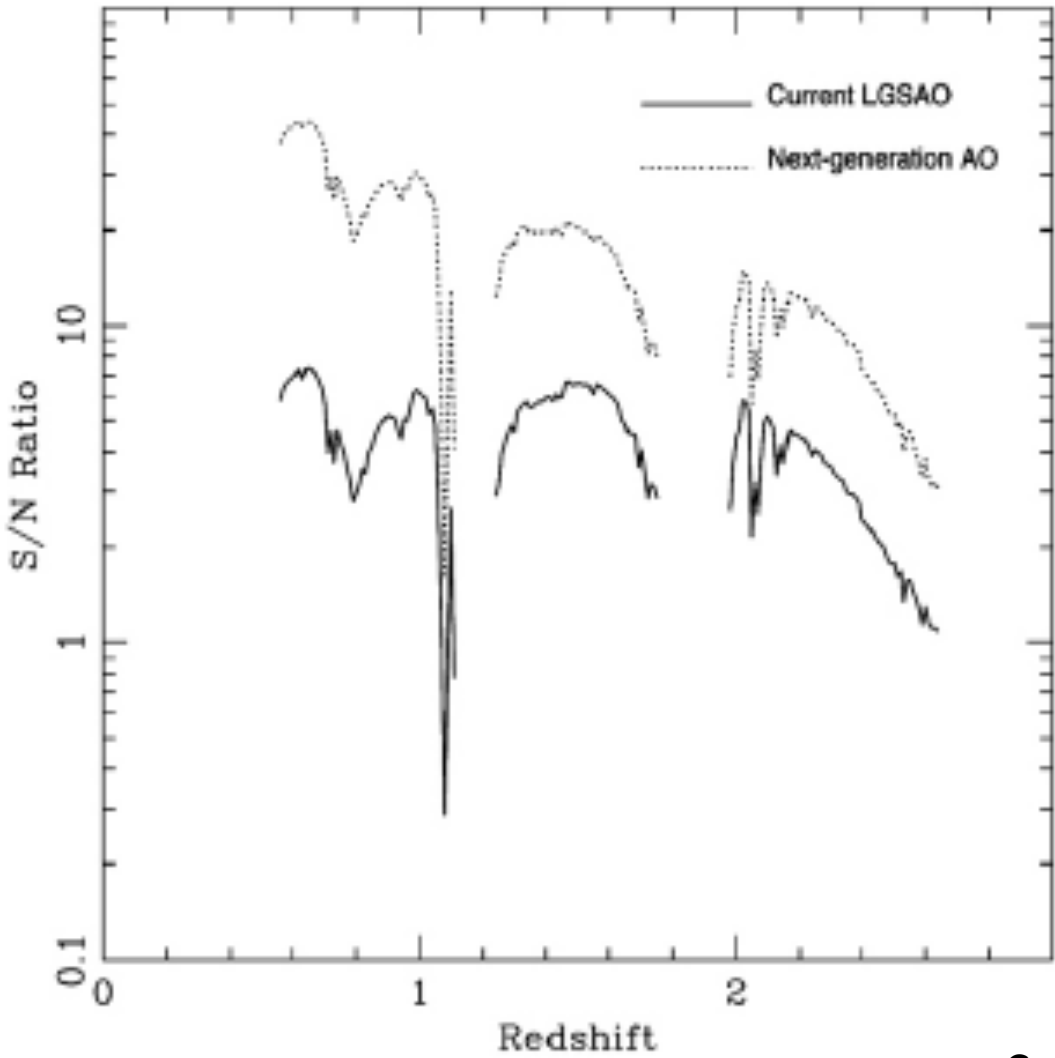
- NGAO: same Strehl at Ca Triplet as LGS today in H band
- NGAO: better Strehl at J band than LGS today in K band
- NGAO: **much** higher sky coverage

# Sky coverage of NGAO is dramatically better than Keck 2 LGS AO

Galaxy Assembly science case (b=60)  
Median seeing, sodium return a bit worse than average



# Dramatic Improvement in Sensitivity



Curtsey of David Law

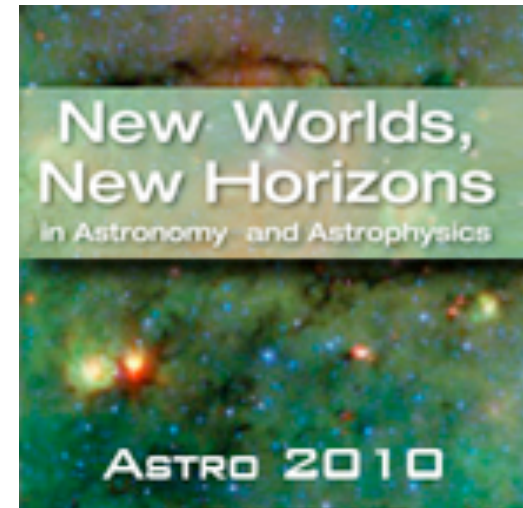
# AOAG Early Assessment

- NGAO remains a flagship for WMKO
  - Broad and important science (strehl & sky coverage)
  - Increasing interactions with TMT
  - Key to our future success as a world-class observatory
- New Fund-Raising Opportunities
  - Mid-Scale program at NSF
  - Keck 20<sup>th</sup> Gala & Science Celebration



# Mid-Scale Innovations Program

- Recommended by Decadal Survey (Astro2010) *August 2010*
  - NGAO was given as an exemplar (1 of 7)
- Reinforced by NSF Astronomy Portfolio Review *August 2012*
- Acknowledged by NSF Astronomy Response *August 2012*
- NSF evaluating Mid-scale program across Math and Physical Sciences (MPS) *Now*
- NGAO well-positioned to propose
  - PDR passed, including a good cost estimate
  - Since PDR, significant risk reduction underway.

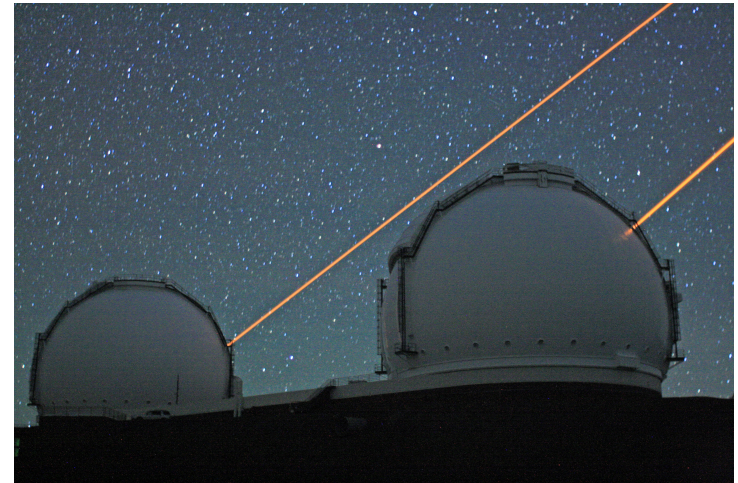


# Keck 20<sup>th</sup> Gala a Great Opportunity

- Clearly communicate to broad audience that NGAO is Keck's Flagship
  - Institutional leadership
  - Foundations (increasing interest in AO)
  - Donors
  - Federal Funding Agencies
- Create a community of financial supporters
  - Existing Friends of Keck have significant resources
  - Reach new potential donors
    - Friends of Keck network
    - Friends of Partners
      - UC inviting 150 potential donors
      - UCLA is already actively engaged

# Next Steps for AOAG

- Prepare for NSF proposal opportunity for mid-scale program (e.g., update science case, re-evaluate competitive landscape)



- Create a private fund-raising strategy
- Assess benefits & priority of additional staged implementation steps and AO improvements